SEISMIC ANALYSIS AND DESIGN OF MULTISTORIED RCC BUILDING WITH VARIOUS CONFIGURATIONS OF SHEAR WALLS.

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Abstract: A shear wall is used to resist the shear, produce due to lateral forces. Shear walls are provided to increase the strength and stiffness of the buildings when the exterior walls cannot provide sufficient strength and stiffness. It is necessary to find out that effective location of shear wall in building. These present work deals with a study influence on seismic performance of location of shear walls in high rise building. This study explained about the 15-story building is considered with a story height of 3.2m and plan dimension 24 x24m. These buildings were analyzed and designed as per the Indian Code of Practice for Seismic Resistant Design and for wind load calculation. For these buildings assumed base supports are fixed. The buildings are modeled and analyzed using software ETABS Ultimate 19 different models are studied with and without shear wall at different position in the building. In this analyzed for story drift and story displacement with (Zone- V) by using Equivalent Static method. Also in these building story drift, story displacement and base shear analyzed for seismic loading with all Zones (Zone-II, III, and IV & V) is considered. The analysis of these building is performed by using dynamic method (Response spectrum analysis).

Keywords: Shear wall, ETABS 19, Equivalent static method, RSA method, , Locations of shear walls.

1. INTRODUCTION

The previous records of earthquake, there is increase in the demand of earthquake resisting building which can be completed by providing the shear wall systems in the building. Due to the major earthquakes in the recent pasts the codal provisions revised and implementing more demand on earthquake design of the structure. The decision regarding provision of shear wall to resist lateral forces effectively play most important role in selecting the appropriate structural system for these project. Generally structures are subjected to two types of loads system that is Static and Dynamic. Static loads are constant does not change with time. While dynamic loads are varying with Regular time.

In majority high rise building structures only static loads are considered than dynamic loads. The dynamic load are not calculated because the calculations are more be complicated. This may be cause disaster particularly during Earthquake due to seismic waves. By providing shear wall in multistoried building we can resist seismic waves of earthquake. The loads are calculated by E-TABS 19 software by providing shear walls at various parts of building. The design and analyses of the structures by considering seismic effect. The research works to be done regarding the study of multistory RC frame structure with lateral load resisting systems such as shear wall system. The present work concerned with the comparative study of seismic analysis of multi-storied building with shear wall analysis of multi-storey structure of different shear wall locations .The proper location of shear wall in the multi-storey building etc. [1]. High-rise buildings are becoming more slender, leading to the possibility of more sway in comparison with earlier high rise buildings .improving the structural systems of high rise buildings can control their dynamic response [2]. The Various positions of core shear wall are modeled and were analyzed for Displacement and Drift under static earthquake loading in V earthquake zone of India[3]. These wall will consumptives shear forces and will prevent changing location-position of construction and consequently destruction. On other hand, shear wall arrangement must be absolutely accurate.[4]. The study of high rise building with 15 storey's in zone v is considered for building models. The five different type of models are considered in every location of building by changing location of shear wall in structure plan viz., at corners, edge, inner edge, Center of the building and central core section of the building.[5].

2. PROBLEM STATEMENTS

2.1.To perform comparative seismic analysis of multistoried buildings with and without shear walls.

To achieve this objective different techniques will be used for design and analysis Of RCC framed structure. By applying suitable technique multistoried buildings will be designed with influence of shear wall. These buildings will be analyzed for seismic load in compare with and without shear wall and the results will compare.

2.2.To analyze influence on seismic performance of location of shear walls to identify the appropriate locations.

To achieve this objective we will study different location of shear walls in buildings with same grades of materials are compared. From the comparative results obtained the adequate location of shear walls on seismic performance of building is studied and conclusion will made.

3. METHODOLOGY

In this study the 15-story building is considered with each story height of 3.2m and plan dimension (24 x24m). as per the Indian Code, These buildings are analyzed and designed These buildings are analyzed and designed for Seismic Resistant Design and for wind load calculation. For the buildings base supports are assumed to be fixed. The buildings are modeled and analyzed using software ETABS Ultimate 19 different models are studied with and without shear wall at different position in the building. In this analyzed for storey drift and story displacement with (Zone- V) by using Response Spectrum Analysis method. Also in these building storey drift, story displacement and base shear analyzed for seismic loading with all Zones (Zone-II, III, and IV & V) is considered. The analysis of these building is performed by using dynamic method (Response spectrum analysis). In this Performance structure is analyzed by both methods Equivalent static and Response spectrum.

3.1 Different Locations And Shapes Of Shear Walls

The location and shape of the shear wall have significant effect on the structural behavior under lateral loads. Lateral loads are distributed through the horizontal diaphragm of building structure, to the shear walls, parallel to the force of the action. The core eccentrically located with respect to the building locations has to carry out torsion as well as bending and direct shear. The Shear Wall location and shapes used in this work are,

(a) At Edge
(b) At Corner
(c) At Core
(d) C – Shape
(e) S – Shape

3.2. Modelling Of Building

Here the study is carried out for the behavior of G+15 and building with shear walls of five different location and shapes in all zones. The general software ETABS ultimate 19 has been used for the modeling. It is more user friendly and versatile program that offers the wide scope of the features like static and dynamic analysis, non- linear dynamic analysis and nonlinear static pushover analysis, etc.

3.3 Building Plan And Dimension Details

Sr.no	Specifications	size
1	Plan Dimensions	24m X 24m (X*Y)
2	Length in X Direction	16m (4 Bays), 8m (1Bay)
3	Length in Y Direction	24m (6 Bays)
4	Total Height Of Building	48.8m
5	Floor to Floor Height	3.2m
6	Column Size	500mm X 650mm , 400mm X 500mm.
7	Beam Size	300mm X 500mm.
8	Slab Thickness	150mm.
9	Shear Wall Thickness	230mm.
10	Grade Of Concrete	M25, M30.
11	Grade Of Steel	HYSD 500

Table 1. Building Plan And Dimension Details.

3.4 Loadings

Sr.no	Specifications	Data
1	Dead Load	1 KN/M2
2	Live Load	4 KN/M2
3	Floor Finish Load	1.5 KN/M2
4	Seismic Loading	IS: 1893
5	Zone Factor	0.36 (Zone – V)
6	Soil Type	II
7	Importance Factor	1.5
8	Response Reduction Factor	5
9	Eccentric Ratio	0.05
10	Wind Loading	IS: 875
11	Wind Speed	44 m/s
12	Risk Coefficient K1	4
13	Terrain Categories K2	4
14	Topography K3	1.05

Table 2. Loadings.

3.5 Model Details

Consider RC frame shear wall building of 15 stories with and without shear wall at different position for regular and irregular structure. Total of 6 models are considered for analysis:-

Model 1: Regular building with shear wall at Edge.

Model 2: Regular building with C Shape shear wall at Inner Edge.

Model 3: Regular building with shear wall at Corner.

Model 4: Regular building with shear wall at Core.

Model 5: Regular building with S Shape shear wall at center.

Model 6: Regular building without shear wall.

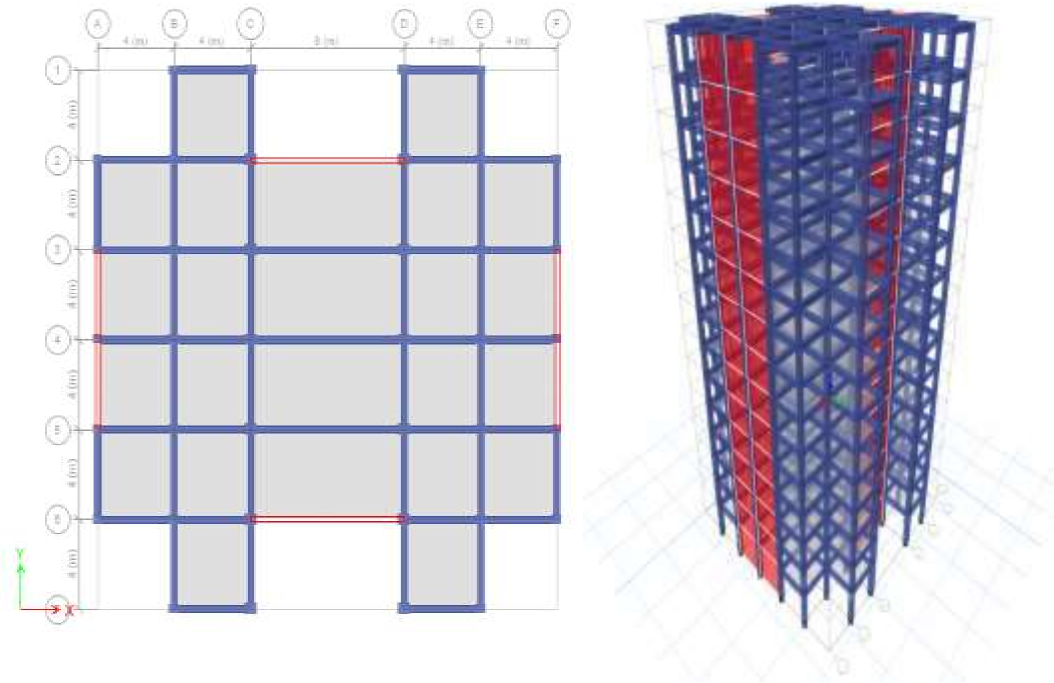

Fig 1. Model 1 Regular building with shear wall at Edge

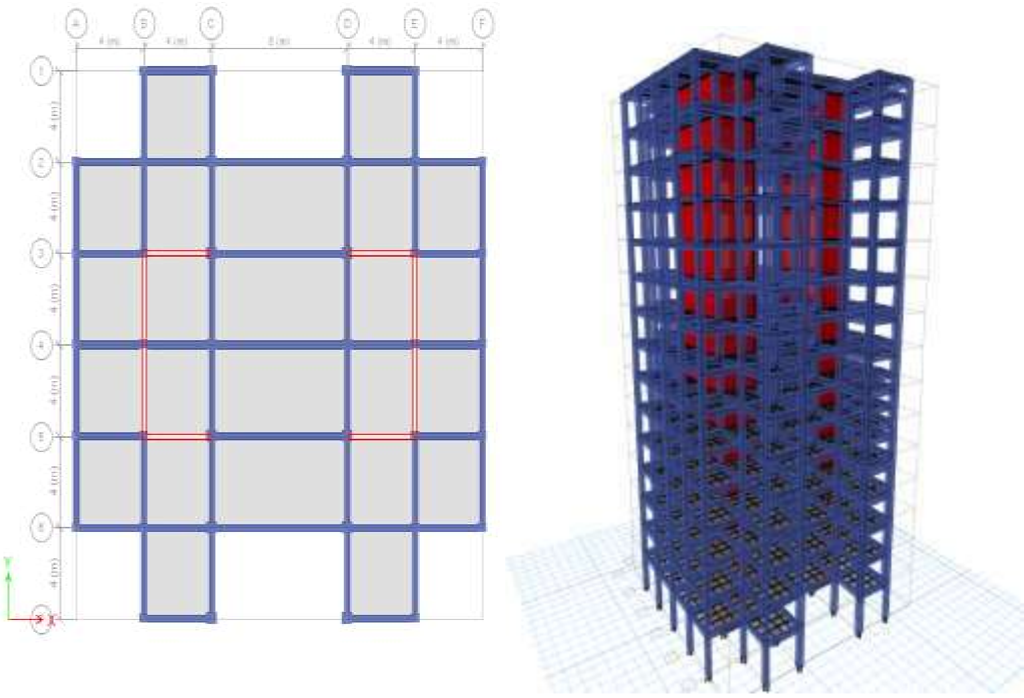

Fig 2. Model 2 Regular building with C Shape shear wall at Inner Edge.

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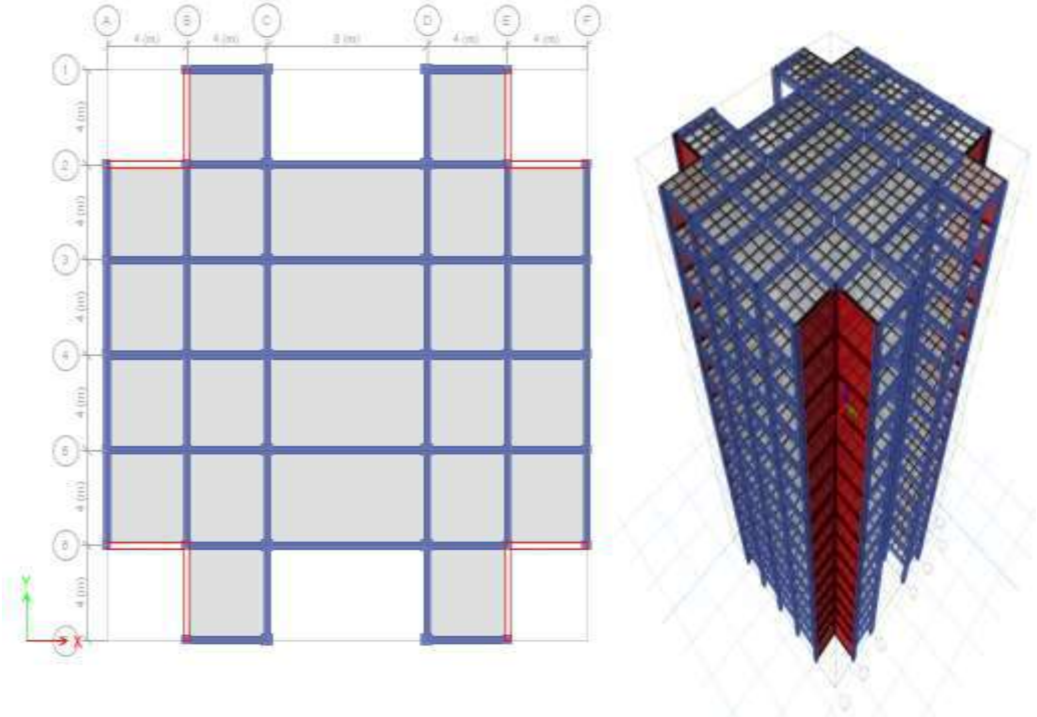

Fig 3. Model 3 Regular building with shear wall at Corner.

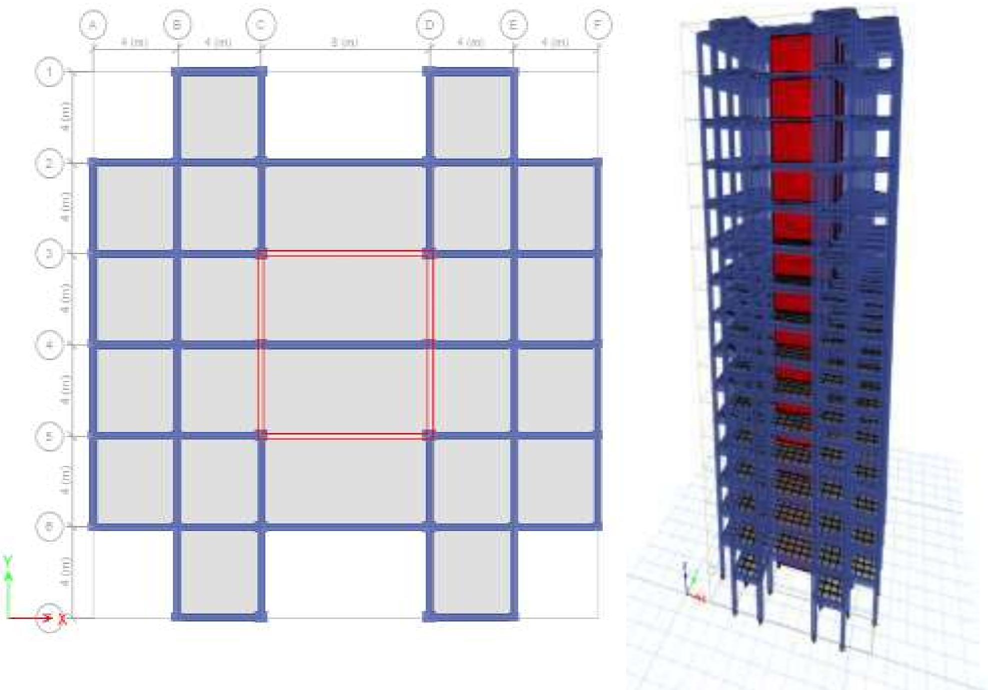

Fig 4. Model 4 Regular building with shear wall at Core

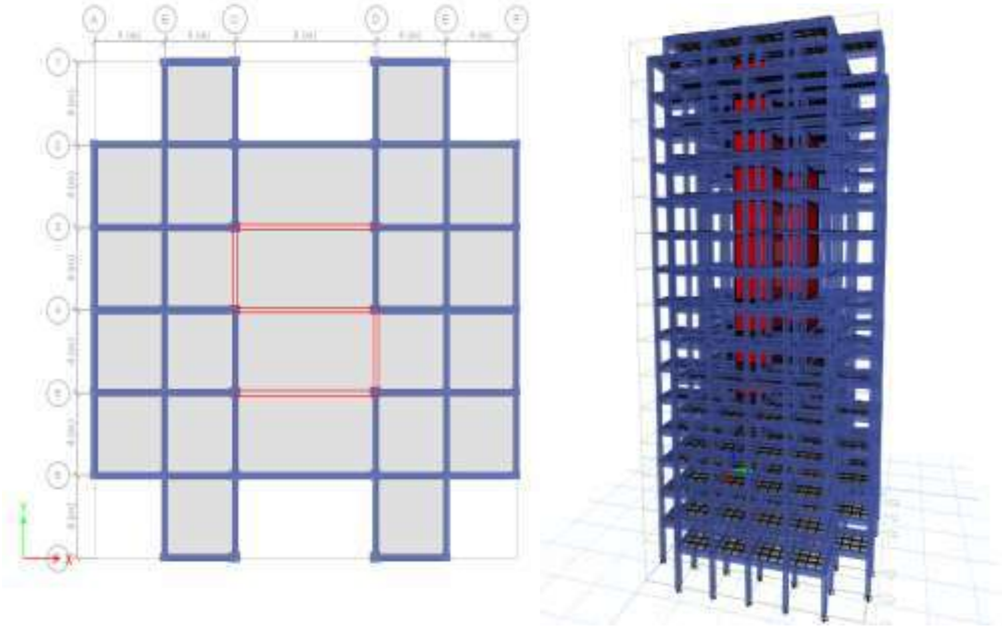

Fig 5. Model 5 Regular building with S Shape shear wall at center.

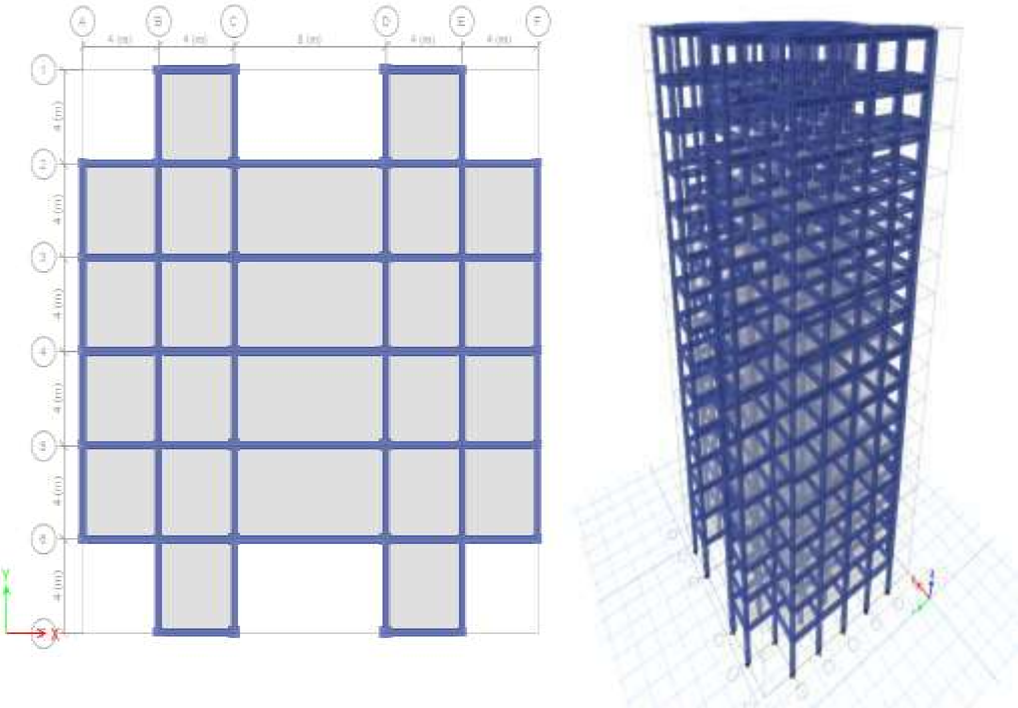

Fig 6.Model 6 Regular building without shear wall.

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4. RESULTS AND DISCUSSION

To study the response of lateral load effect on structure we used RC frame 15 storied a building with shear wall at different location for seismic zone V and wind load. This Analysis is done by using Response Spectrum Analysis. To check performance comparative seismic analysis of multistoried buildings with and without shear walls. From the comparative results obtained the adequate location of shear walls on seismic performance of building is studied and conclusion will made.

Model 1: Regular building with shear wall at Edge.
Model 2: Regular building with C Shape shear wall at Inner Edge.
Model 3: Regular building with shear wall at Corner.
Model 4: Regular building with shear wall at Core.
Model 5: Regular building with S Shape shear wall at center.
Model 6: Regular building without shear wall

Table 1 : Lateral Storey Displacement for Building in X-Direction for Response Spectrum Analysis (RSA)

Response Spectrum Analysis						
MAX Displacement in X Direction (mm) (ZONE V)						
Storye	Model 1	Model 2	Model 3	**Model 4**	Model 5	Model 6
15	21.318	27.119	27.999	**17.087**	18.254	42.104
14	19.782	25.088	25.864	**15.820**	16.910	41.063
13	18.197	23.012	23.688	**14.511**	15.535	39.676
12	16.573	20.898	21.479	**13.174**	14.142	37.938
11	14.914	18.753	19.242	**11.816**	12.736	35.884
10	13.229	16.588	16.991	**10.449**	11.327	33.545
9	11.531	14.419	14.741	**9.085**	9.927	30.949
8	9.838	12.268	12.514	**7.740**	8.553	28.118
7	8.172	10.159	10.337	**6.430**	7.221	25.069
6	6.558	8.124	8.239	**5.174**	5.951	21.816
5	5.026	6.197	6.259	**3.992**	4.764	18.370
4	3.612	4.422	4.442	**2.905**	3.686	14.741
3	2.357	2.851	2.841	**1.939**	2.743	10.944
2	1.308	1.546	1.520	**1.121**	1.665	7.033
1	0.517	0.58	0.554	**0.478**	0.384	3.207
0	0	0	0	**0**	0	0

Fig 7 MAX Displacement in X Direction (mm) (ZONE V)

Table 2 : Lateral Storey Displacement for Building in y-Direction for Response Spectrum Analysis (RSA)

Response Spectrum Analysis						
MAX Displacement in Y Direction (mm) (ZONE V)						
Storye	Model 1	Model 2	Model 3	**Model 4**	Model 5	Model 6
15	23.93	27.119	27.055	**17.699**	20.189	40.242
14	22.161	25.088	25.045	**16.351**	18.981	39.589
13	20.345	23.012	22.993	**14.966**	17.694	38.559
12	18.494	20.898	20.902	**13.556**	16.337	37.157
11	16.611	18.753	18.775	**12.131**	14.916	35.417
10	14.705	16.588	16.623	**10.7**	13.442	33.37
9	12.792	14.419	14.462	**9.277**	11.927	31.039
8	10.89	12.268	12.311	**7.878**	10.388	28.444
7	9.023	10.159	10.197	**6.521**	8.841	25.601
6	7.22	8.124	8.15	**5.224**	7.305	22.524
5	5.513	6.197	6.209	**4.009**	5.8	19.222
4	3.942	4.422	4.419	**2.898**	4.354	15.705
3	2.552	2.851	2.835	**1.919**	3	11.975
2	1.398	1.546	1.522	**1.098**	1.785	8.052
1	0.54	0.58	0.558	**0.466**	0.777	4.013
0	0	0	0	**0**	0	0

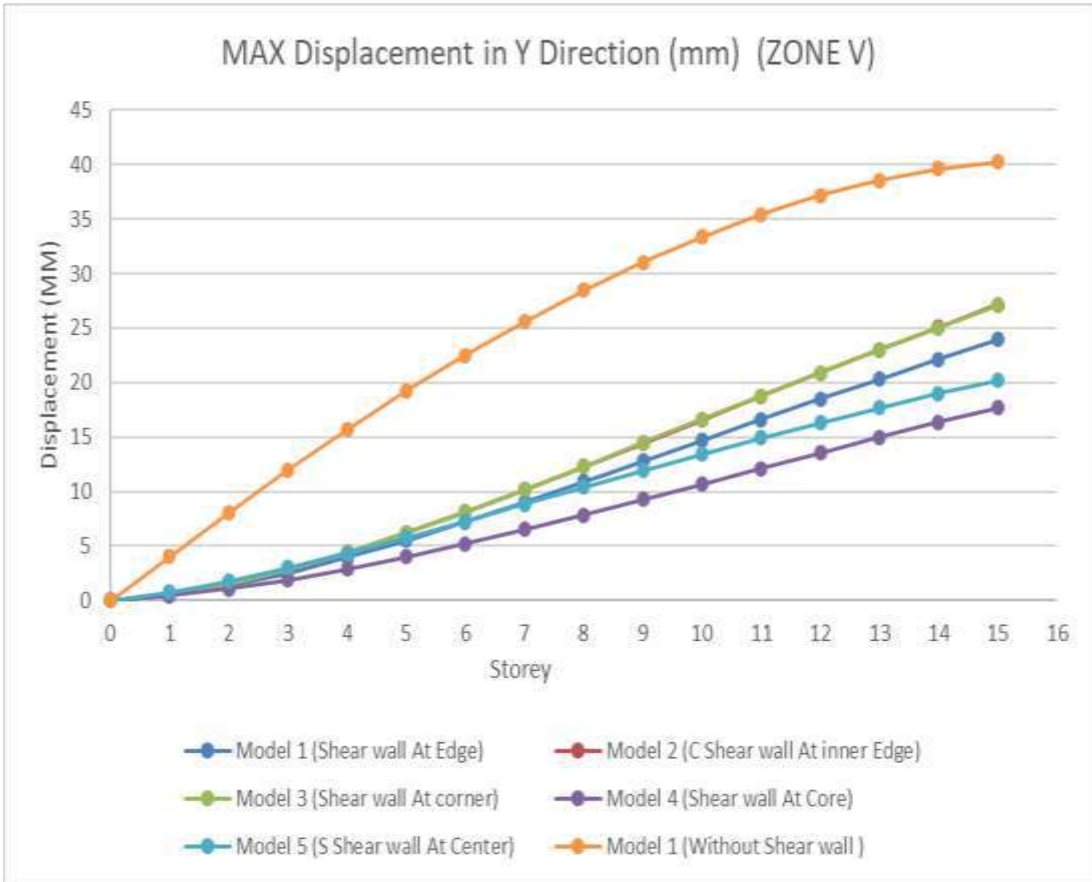

Fig 8. MAX Displacement in Y Direction (mm) (ZONE V)

Table 3 : Storey Drift for Building in X-Direction for Response Spectrum Analysis (RSA)

Response Spectrum Analysis						
MAX Storey Drift in X Direction (mm) (ZONE V)						
Storye	Model 1	Model 2	Model 3	**Model 4**	Model 5	Model 6
15	0.000489	0.00065	0.000683	**0.0004**	0.000424	0.000393
14	0.000507	0.000668	0.0007	**0.00041**	0.000434	0.000544
13	0.00052	0.000682	0.000712	**0.00042**	0.000441	0.000681
12	0.000531	0.000693	0.000721	**0.00043**	0.000445	0.000787
11	0.000539	0.000698	0.000725	**0.00043**	0.000446	0.000871
10	0.000542	0.000697	0.000722	**0.00043**	0.000443	0.00094
9	0.000539	0.000688	0.000712	**0.00043**	0.000434	0.000999
8	0.000528	0.000672	0.000693	**0.00041**	0.00042	0.001049
7	0.00051	0.000646	0.000665	**0.0004**	0.0004	0.001094
6	0.000483	0.000609	0.000625	**0.00037**	0.000373	0.001136
5	0.000444	0.000559	0.000572	**0.00034**	0.000338	0.001173
4	0.000394	0.000493	0.000502	**0.0003**	0.000296	0.001206
3	0.000329	0.000409	0.000414	**0.00026**	0.000244	0.001229
2	0.000248	0.000302	0.000302	**0.0002**	0.000182	0.001197
1	0.000129	0.000145	0.000138	**0.00012**	9.60E-05	0.000802
0	0	0	0	**0**	0	0

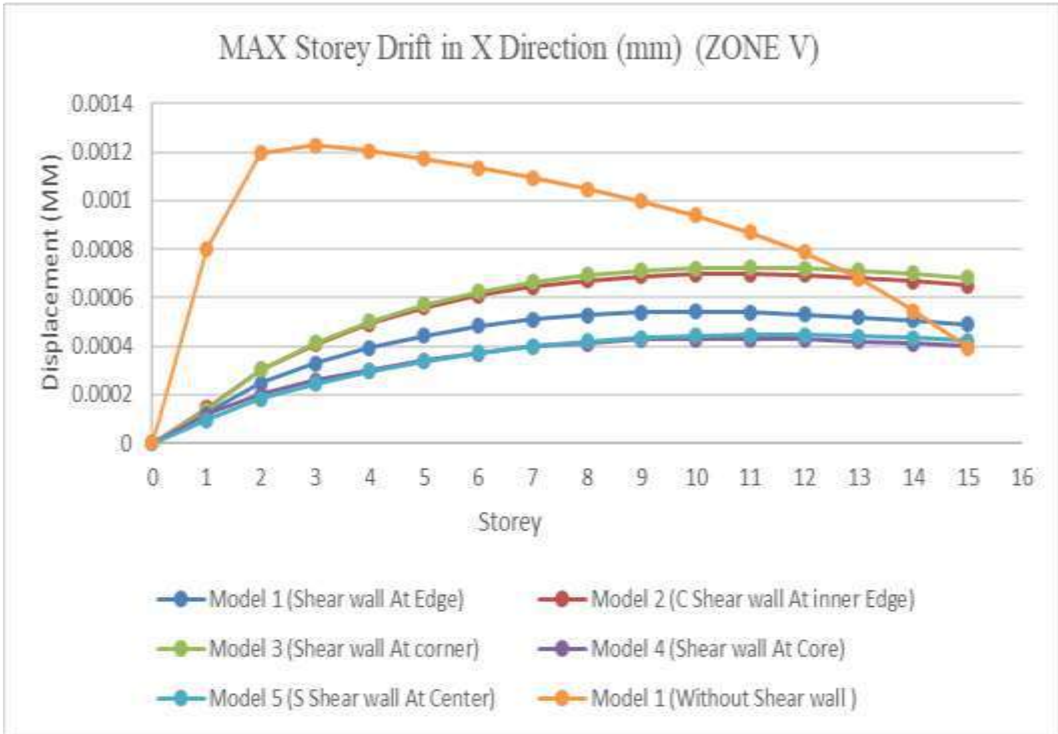

Fig 9. MAX Storey Drift in X Direction (mm) (ZONE V)

Table 4 : Storey Drift for Building in y-Direction for Response Spectrum Analysis (RSA)

Response Spectrum Analysis						
MAX Storey Drift in Y Direction (mm) (ZONE V)						
Storye	Model 1	Model 2	Model 3	**Model 4**	Model 5	Model 6
15	0.000564	0.00065	0.000645	**0.00043**	0.000388	0.000271
14	0.000581	0.000668	0.000661	**0.00044**	0.000417	0.000436
13	0.000594	0.000682	0.000675	**0.00045**	0.000442	0.000579
12	0.000605	0.000693	0.000687	**0.00045**	0.000464	0.000689
11	0.000611	0.000698	0.000694	**0.00045**	0.000481	0.000777
10	0.000612	0.000697	0.000694	**0.00045**	0.000493	0.000854
9	0.000606	0.000688	0.000688	**0.00044**	0.000498	0.000921
8	0.000593	0.000672	0.000673	**0.00043**	0.000497	0.000982
7	0.00057	0.000646	0.000648	**0.00041**	0.000491	0.001039
6	0.000538	0.000609	0.000613	**0.00038**	0.000478	0.001091
5	0.000494	0.000559	0.000563	**0.00035**	0.000457	0.00114
4	0.000436	0.000493	0.000497	**0.00031**	0.000426	0.001187
3	0.000362	0.000409	0.000411	**0.00026**	0.000381	0.001234
2	0.000269	0.000302	0.000302	**0.0002**	0.000315	0.001263
1	0.000135	0.000145	0.000139	**0.00012**	0.000194	0.001003
0	0	0	0	**0**	0	0

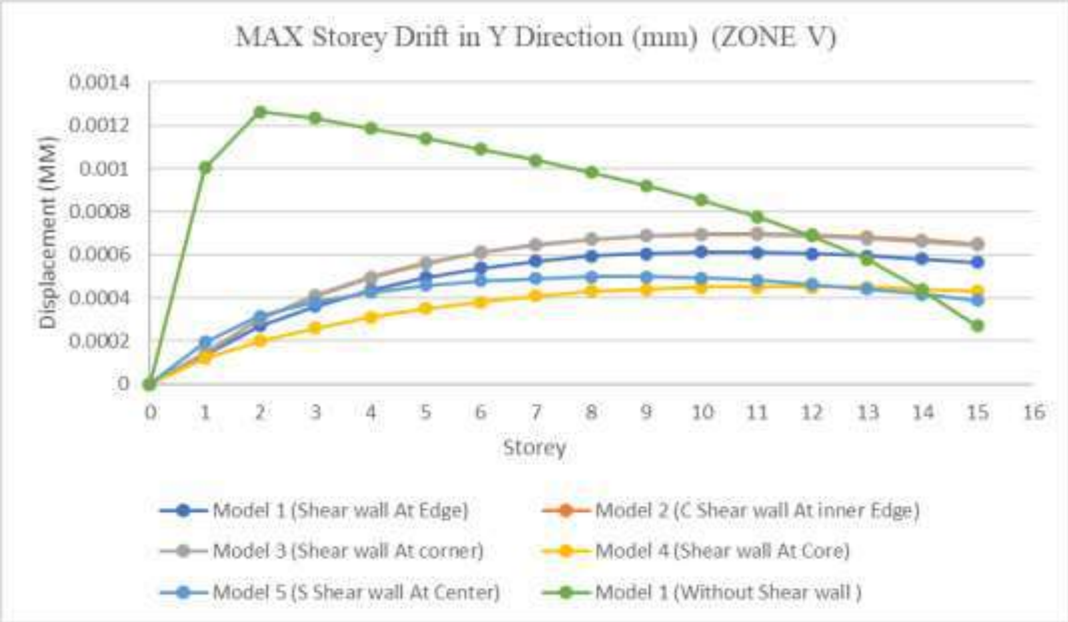

Fig 10. MAX Storey Drift in Y Direction (mm) (ZONE V)

Above fig shows displacement v/s no. of storeys for regular Building model having shear wall at different location along X-direction for seismic zone V and wind load, analyses is carried out for Response Spectrum Analysis (RSA)

From graph plotted indicates that:

1) The maximum displacement along X-direction for regular structure without shear wall is 42.10mm.
2) The maximum displacement along y-direction for regular structure without shear wall is 40.247mm.
3) The maximum displacement along X-direction for regular structure with shear wall at Core Section is 17.08mm
4) The maximum displacement along Y-direction for regular structure with shear wall at Core Section is 17.70mm

From Above Result , The shear wall is provided at core of building structure its gives Better Performance as compared to Other placing location .The Comparative Analysis of structure with and without shear wall is given below.

1) The Displacement of regular structure with shear wall at core of building is 40.57% Comparative less than regular structure without shear wall in X-Direction.
2) The Displacement of regular structure with shear wall at core of building is 44.01% Comparative less than regular structure without shear wall in Y-Direction.

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5. Conclusion

1. The displacement of storey, has been reduced for all structures with shear walls as compared to without shear wall for regular structure.
2. The analysis of building with Core shear wall and shows that stiffer behavior when shear wall provide at core.
3. When shear walls are provided on corner maximum storey displacement of buildings is increased comparing to when shear walls are provided at core.
4. The maximum lateral storey displacement exists at the top storey level for all types of structures.
5. The shear walls in structure increase the strength of the structure to resists the lateral forces by increasing the performance of the structure.

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EXPERIMENTAL STUDY ON "REPLACEMENT OF STEEL REINFORCEMENT BY BAMBOO REINFORCEMENT"

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Abstract: The following research paper is a theoretical demonstration of comprehensive use of bamboo as a reinforcing material in concrete construction and its extensive use in the substitution with steel as reinforcement in concrete load bearing members. The research paper has been derived with the help of conclusions and results of research paper of various conducted experiments for determining the mechanical properties of bamboo and its use as a material in construction. The construction principles involved in the designing of bamboo reinforced members and structure has been discussed in this document the use of bamboo in the place of steel as a whole as well as with steel is shown to ensure the reduction of weight, economic advantage with its strength compromised to a slight and safe level. A method that would not compromise with the factor of safety of the structure has to be shown in the report. Recently, in the attention in response to global warming issues and sustainable society, the manufacturing using natural materials has become actively. Bamboo, low cost, fast growing, and broad distribution of growth, is expected to contribute significantly to earthquake-resistant construction and seismic retrofit.

Keywords: **Bamboo, Flexural Strength, Tensile Strength, Mechanical properties**

INTRODUCTION

The use of bamboo as reinforcement in Portland cement concrete has been studied extensively by the Clemson Agricultural College. Bamboo has been used as a building material globally by the human civilization since a very long period of time but after the Clemson study, its use as reinforcement has gained little attention. A study of the feasibility of using bamboo as the reinforcing material in precast concrete elements was conducted at the U. S. Army Engineer Waterways Experiment Station in1964. Ultimate strength design procedures, modified to take into account the characteristics of the bamboo reinforcement were used to estimate the ultimate load carrying capacity of the precast concrete elements with bamboo reinforcing. This study has been taken as a reference in the study conducted henceforth. The investigation of the use of bamboo as a complimentary material with steel in RCC construction has been shown in this study with the economy, safety, convenience and durability of application of the particular idea. Since the use of bamboo in the ancient times for housing purposes, it has been diminishing in our world in the form of a building material in despite its rich properties, strength and economic advantages. The strength can be revamp by using different materials as stirrups in several dimensions. Studies shows that the usage of bamboo as a reinforcing material has been increased for the past few years and it was proved to be best alternative for steel for reinforcing the concrete.

BAMBOO AS A CONSTRUCTION MATERIAL

Through research it has been found that some species of bamboo have ultimate tensile strength same as that of mild steel at yield point. Experimentally it has been found that the ultimate tensile strength of some species of bamboo is comparable to that of mild steel and it varies from 140N/mm2- 280N/mm2. Bamboo is a versatile material because of its high strength-to-weight ratio, easy workability and availability. Bamboo needs to be chemically treated due to their low natural durability. It can be used as Bamboo Trusses, Bamboo Roofs Skeleton, Bamboo walling/ceiling, Bamboo Doors and Windows, Bamboo Flooring, Reed Boards, Scaffolding.

OBJECTIVES

- Designing beam in which bamboo as a reinforcing material and comparing with ordinary reinforced beam.
- To compare cost of bamboo reinforced beam with steel reinforced beam.
- To conduct flexural strength test on steel reinforcement beam and bamboo reinforcement beam.
- To compare tension behaviour of steel and bamboo.
- To compare the efficiency of bamboo reinforced concrete against steel reinforced concrete.

SCOPE OF WORK

- Bamboo is a versatile material because of its high strength-to-weight ratio, easy workability and availability.
- The Analysis of the replacement of steel with bamboo as reinforcement shows that reinforcement with bamboo is quite cheaper than that of steel reinforcement.
- Many new techniques are being developed which may make bamboo the best

constructional material in future.

- It has wide scope in Low Cost.

METHODOLOGY

STEP 1: Designing steel reinforced beam in stadd.pro software and comparing it with bamboo reinforced beam.

STEP 2: Find out the quantities of steel and bamboo reinforcement. Costing of steel reinforcement and bamboo reinforcement and compare the cost of both.

STEP 3: Design, Casting of steel reinforced beam and bamboo reinforced beam. Compare the flexural strength of both.

STEP 4: Testing of steel and bamboo bars in Universal Testing Machine. And compare behavior of both.

STEP 5: Compare the efficiency of bamboo reinforced concrete against steel reinforced concrete.

PROPERTIES OF BAMBOO

- Specific gravity – 0.575 to 0.655
- Average weight – 0.625 kg/m
- Modulus of elasticity – 1.5 to 2.0 x 10^5 kg/cm^2
- Ultimate compressive stress – 794 to 894 kg/cm^2
- Safe working stress in compression – 105 kg/cm^2
- Safe working stress in tension – 160 to 350 kg/cm^2
- Safe working stress in shear – 115 to 180 kg/cm^2
- Bond stress – 5.6 kg/cm^2

SELECTION AND PREPARATION OF BAMBOO

SELECTION

The following factors should be considered in the selection of bamboo culms (whole plants) for use as reinforcement in concrete structures:

 Use only bamboo showing a pronounced brown color. This will insure that the plant is at least three years old.
 Select the longest large diameter culms available.
 Do not use whole culms of green, unseasoned bamboo.
 Avoid bamboo cut in spring or early summer. These culms are generally weaker due to increased fibre
moisture content.

PREPARATION

- Sizing- Splints are generally more desirable than whole culms as reinforcement. Larger culms should be split into splints approximately 3/4 inch wide. Whole culms less than 3/4 inch in diameter can be used without splitting.

Splitting the bamboo can he done by separating the base with a sharp knife and then pulling a dulled blade through the stem. The dull blade will force the stem to split open; this is more desirable than cutting the bamboo since splitting will result in continuous fibres and a nearly straight section

- Seasoning- When possible, the bamboo should be cut and allowed to dry and season for three to four weeks before using. The culms must be supported at regular spacing's to reduce warping.

DESIGN OF BEAMS

DESIGN OF STEEL BEAM

As per IS 456-2000

Size of beam= 200mm x 250mm

Length of beam=2m

Design of singly reinforced R.C.C. beam

Tension reinforcement;

Provide 12mm diameter bar of 4 numbers @30mm c/c.

Shear reinforcement;

Provide 2legged 8mm diameter stirrups @ 250mm c/c.

DESIGN OF BAMBOO BEAM

Size of beam= 200mm x 250mm

Length of beam=2m

Bamboo longitudinal reinforcement should be between 4% to 6% of the concrete cross section;

It have the same bending moment resistance coefficient as a balanced steel reinforced beam doubly reinforced.

No. of bamboo bar = 8

Diameter of bamboo = 25mm

Spacing= (width-(2xclear cover + 2 x stirrups dia + n x bar dia))/(n-1)

Spacing= 25mm c/c

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CONSTRUCTION PROCEDURE

In general, techniques used in conventional reinforced concrete construction need not he changed when bamboo is to be used for reinforcement.

Concrete Mix Proportions - The same mix designs can be used as would normally be used with steel
reinforced concrete. Concrete slump should be as low as workability will allow. Excess water causes swelling of the bamboo. High early-strength cement is preferred to minimize cracks caused by swelling of bamboo when seasoned bamboo cannot be waterproofed.

Placement of bamboo- Bamboo reinforcement should not be placed less than 1.5 inches from the face of the concrete surface. When using whole culms, the top and bottom of the stems should be alternated in every row and the nodes or collars, should be staggered. This will insure a fairly uniform cross section of the bamboo throughout the length of the member, and the wedging effect obtained at the nodes will materially increase the bond between concrete and bamboo.
The clear spacing between bamboo rods or splints should not be less than the maximum size aggregate plus 1/4 inch. Reinforcement should be evenly spaced and lashed together on short sticks placed at right angles to the main reinforcement. When more than one layer is required, the layers should also be tied together. Ties should preferably be made with wire in important members. For secondary members, ties can be made with vegetation strips.

Fig.1 Preparation of specimen

Fig.2 Casting of Beam

TESTING OF BEAM SPECIMEN

The beam specimens were loaded by two-points loading produced by a hydraulic-piston supported on a rigid steel frame. A spreader beam transferred the load symmetrically to ensure pure bending at mid span of the beam. Load at mid-point was directly recorded whereas the mid-span deflection was measured with LVDT (linear variable differential transformers) attached parallel on the specimen. The load and deflection values were used to develop load deflection plots.Appearance of cracks were visually inspected during the loading. The beam specimens were subjected to the load up to the failure point, as can be seen in Figure.

Fig.3 Testing of Beam under Loading Frame

RESULTS AND ANALYSIS

Table 1: Flexural capacity concrete beams

BEAM SPECIMEN	Fc (MPa)	Maximum load (kN)	Flexural Moment (kNm)
Bamboo Reinforced Beam	51.70	109.00	38.15
Steel Reinforced Beam	58.77	260.0	91.00

Table 2: Ductility of reinforced concrete beam

BEAM SPECIMEN	YIELD CONDITION		ULTIMATE CONDITION		DUCTILITY $\mu = \Delta u/\Delta y$ $\Delta u/\Delta y$
	LOAD (P) kN	DEFLECTION (Δy)	LOAD (P)	DEFLECTION (Δy)	
Bamboo Reinforced Beam	98.3	21.07	10.90	28.70	1.322
Steel Reinforced Beam	245.2	10.78	26.00	18.47	1.713

CONCLUSIONS

The results and data processing that carried out, several conclusions as follows:

1. Bending collapse of beams as planned, which is bending failure.
2. Bamboo Reinforced Concrete has not been able to completely replace steel reinforcement.
3. Bamboo as reinforcement can only be used in structures where light loads are being imparted.
4. Steel and bamboo will be used together wherever required and not more than 25% of steel in a member can be replaced while in the whole structure, not more that40% should be replaced.
5. Therefore it has been concluded that a structure can be reinforced with bamboo in the zones where compression has to be tackled.
6. Bamboo can also be used as reinforcing the partition walls, but unlike all the load bearing members, 100% of steel can be replaced which will proveto be better than steel as in seismic proofing and prevent the walls from losing integrity bythe nature of its stiffness.

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EXPERIMENTAL STUDY ON THE POROUS CONCRETE

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Abstract: Pervious concrete, porous concrete, or water permeable concrete is a kind of concrete having a high void content that enables water and air to flow through. When water from precipitation and other sources are allowed to flow through pervious concrete (also known as a high-porosity concrete, permeable concrete, no-fines concrete, or porous pavement), it reduces runoff and allows groundwater to be recharged. Large particles are used in pervious concrete, whereas small aggregates are used sparingly. The aggregates are then coated with the concrete paste, which enables water to travel through the slab. It's a crucial application for sustainable building, and it's only one of several low-impact development approaches that builders utilize to maintain water quality. Porous Concrete, also known as dry concrete other than shattered concrete, no fines concrete, and porous concrete, is an exceptionally robust structure used in the construction industry. A significant component is water. Penetrable concrete is a unique kind of strong made up of concrete, coarse aggregates, water, and, if needed, admixtures and specialty cements. In addition, there was a research that looked into porous concert applications. Advantages, Materials needed for concrete grade m40 Test of compression Split tensile strength is a measurement of how strong a material is when it

Keywords: **concrete, water**

1. INTRODUCTION

Over the years, construction technology has seen a dramatic shift. Using improved building methods, many common projects may be completed in a month. It has been shown that no building can be constructed at a cost-effective rate without the use of concrete. When we use the term "concrete," we're really referring to anything that grows together, which is a verb from the Latin. Concrete is a mixture of cement, aggregate, and water that is used in building. Chemical reactions known as hydration are responsible for the formation of concrete once it is mixed and placed. Stone is formed as a result of the reaction between cement and water, which solidifies the other ingredients. There are several uses for concrete in the construction industry, such as pavements, architectural structures and foundations, overpasses, and parking structures. Tensile strength may be increased with the use of reinforcing bars. There are several variables that govern the qualities of concrete while it is wet and when it has hardened, such as how much cement, aggregate, and water are in mixing it up a little. The water-to-cement ratio has a major impact on the strength of concrete. Water-cement ratio increases cause concrete bleeding and weaken the finished product.

Ordinary Portland cement is often used in high-performance concrete. In the concrete business, it is standard practice to include a variety of sub-products into cement-based materials. Concreting using pervious concrete is an innovative new material that is a mixture of coarse aggregate (cement), water, and little to no fine aggregate (sand), allowing air or water to flow through. When compared to traditional concrete, this one enables water to drain naturally through it and replenish the groundwater supply. Also known as "No Fines Concrete," this groundbreaking substance is a game-changer. Pores in pervious concrete may vary from 0.08 to 0.32 inches (2 to 8 mm) in diameter, allowing water to flow through without causing any harm to the matrix of the porous concrete. Land has been drying up recently because of a climatic mismatch, posing a major concern. By using pervious or porous pavement in place of traditional concrete or asphalt for their streets and parking lots, more cities, towns, and companies are able to save money in the long term by reducing storm water runoff and refilling local waterways.

Applications for Porous Concert

- Pavements with a low traffic volume
- Alleys, driveways, and residential roads
- Pathways and sidewalks
- Parking areas
- Low water crossings
- Tennis courts
- Sub-base for conventional concrete pavements
- Patios
- Artificial reefs
- Slope stabilization
- Well linings
- Tree grates in sidewalks
- Greenhouse foundations/floors, fish hatcheries, aquatic amusement facilities, and zoos
- Hydraulic structures
- Swimming pool decks
- Pavement edge drains
- Groins and seawalls
- Noise barriers
- Walls (including load-bearing)

Advantages

Sustainable development may be achieved with the use of pervious concrete. In order to maximize water storage and transportation, pervious concrete is composed of a minimal amount of fine aggregate and evenly proportioned coarse material. One of the low-impact development approaches utilized by builders to safeguard water quantity and quality is sustainable building. Surface runoff may be significantly reduced, reducing the need for storm sewers, as compared to concrete pavement. A tire-to-pavement contact reduces the noise created by automobiles and reduces the cost of an existing device for noise reduction in metropolitan settings. Saving vital natural resources is made possible in the following ways:

- Easy Installation
- Durable
- Sustainable
- Low Cost
- Can Be Temporary
- Can Be Used for Lawn Parking
- Can Create Temporary Roads
- Eliminates Costly Drainage Systems
- Can be Used for Erosion Control
- Natural drainage reduces puddles
- Natural filtration
- Flood prevention
- Reduces the heat island affect
- Natural and sustainable materials

LITERATURE REVIEW

G.Amirthagadeshwaran (2019) High porosity concrete is known as pervious concrete. Groundwater recharge and reduced runoff may be achieved by using this material in concrete flatwork applications. In order to achieve high porosity, the void content must be densely linked. A water-to-cementations-materials ratio of 0.36 is used in pervious concrete. With no fine aggregates, the mixture consists of cementicious ingredients and coarse aggregates. Strength and permeability of porous concrete that includes fly ash as a mix are examined in this article in order to determine if fly ash may be used as a cement alternative. The proportion of fly ash varies between 10% and 20%. Compressive, tensile and water permeability testing is carried out on the samples, and findings are presented.

Harshith, Shashivendra Dulawat et al., (2020) Other names for this kind of concrete include "dry concrete," "no fines concrete," and "porous concrete," which are all variations of the term. A notable component is water. One kind of concrete known as "penetrable" consists of a combination of cement, water, and any admixtures or other cementation ingredients that may be needed. To facilitate water flow, no fine particles are employed in the strong cross section, thus the void material is greater. Solid, water, and course mass admixtures are combined with identifiable cementation ingredients to form permeable concrete. Porous concrete is the subject of a slew of investigations. As its porosity and voids make it seem, the quality characteristics and structure of porous concrete are less favourable when compared to regular concrete. Therefore, despite the fact that it has a section of favourable circumstances, porous concrete must be used. Porous concrete's compressive and flexural properties may be improved, allowing for a plethora of new applications. Light traffic lanes are now the only places where penetrable concrete is commonly used. If the qualities are enhanced, it may also be utilized for medium and large traffic inflexible pavements. Nearby, the permeable concrete collects storm water runoff, aids in groundwater recharge, and allows for the productive use of formerly undeveloped area..

A.Ayyappan, D.Dinesh kumar (2018) Pervious concrete is a kind of high-porosity concrete used for concrete flatwork that allows rainwater and other sources of runoff to pass straight through, reducing runoff and allowing groundwater recharge. This kind of surface is also known as porous concrete, permeable concrete, no fines concrete, and porous pavement. Pervious concrete is made mostly of large aggregates, with very little utilization of smaller particles. The concrete paste used to cover the particles makes it feasible for water to permeate the slab. To reduce drainage system runoff by as much as 30% while still allowing for a water flow rate of 0.34 millimeters per second, this high-void content concrete is becoming more popular today. In addition to being a low-impact development approach, it is a significant application for sustainable building. Parking lots, footpaths, pathways, and roads may all benefit from pervious concrete because of its low-loading-intensity nature. Concrete that is permeable to water, storm water management, and appropriate development is regarded an Environmental Protection Agency (EPA). Cement, inert sand and gravel matrix, or crushed stone are combined to create this composite material. Because of their light colour and open-cell structure, these concretes do not absorb heat from the sun; they also do not reflect the heat back into the atmosphere, which lowers the temperature of the surrounding area.

Amirthagadeshwaran G, Ramesh S, Selvi K (2019) High porosity concrete is known as pervious concrete. Groundwater recharge and reduced runoff may be achieved by using this material in concrete flatwork applications. In order to achieve high porosity, the void content must be densely linked. A water-to-cementitious-materials ratio of 0.36 is used in pervious concrete. With no fine aggregates, the mixture consists of cementicious ingredients and coarse aggregates. Strength and permeability of porous concrete that includes fly ash as a mix are examined in this article in order to determine if fly ash may be used as a cement alternative. The proportion of fly ash varies between 10% and 20%. The specimens are subjected to several testing, including compressive strength, tensile strength, and water permeability.

Sujeet Kumar Saha and Shaik Niyazuddin Guntakal (2018) Pervious concrete is a kind of concrete with a high void or porosity content that allows water to pass through. Permeability of pervious concrete was investigated using four criteria: compression strength, split tensile strength, flexibility, and permeability test. These studies examined the effect of aggregate size (20mm and 10mm), water-to-cement ratio (0.32 & 0.28), super plasticizers, and varying percent fibre content. The results show that a drop in the w/c ratio from 0.32 to 0.28 results in a modest gain in strength, and that super plasticizer also provides excellent strength. The improvement in strength was attributed in large part to the addition of fibre, which accounted for 1 percent of the cement's weight. Although porosity was the most important factor in determining the effectiveness of porous concrete, the inclusion of different percentages of fibre had an impact on this. It was found that the w/c ratio, super plasticizer, fibre, and compaction were all successful in achieving the best strength-to-drain ability balance for a variety of urban purposes.

Yogesh N. Sonawane (2017) Rainwater does not penetrate the earth directly due to the absence of water absorption and air permeability in most ordinary concrete pavements, and as civil engineers and humans, it is our first responsibility to protect the environment. Groundwater levels will drop, making it harder for plants to thrive and for the earth's temperature and humidity to remain stable. Pervious concrete pavement research has been extensively done for road way use in order to reduce such effects. Compressive strength and porosity of pervious concrete will be tested in this investigation. Because of its porosity, compressive strength is reduced, but water absorption is improved. We cannot be employed as a road pavement because of our poor strength. This concrete can only be used for pathways, parking lots, or other low-demand applications.

RESEARCH METHODOLOGY

Permeable concrete is made out of a combination of cement, coarse aggregate (almost no sand), and water. Porous characteristics in concrete are not created with fine aggregates. Admixtures are sometimes used to improve the quality and distinctive characteristics of Porous cement.

CEMENT

System business relies on concrete, which is utilized in a wide variety of ways and produced in a wide variety of buildings. Early improvement in compressive quality aids in covering quickly. Intense Concrete: A Realistic Alternative for Structures Built with a Strong Mix.

AGGREGATES

The area of the strong that contains the larger stones imbedded in the mixture is called Coarse Aggregates. The three fixings in concrete are water, cement, and aggregate, each of which has a specific role to play. Smashed stone or river rock is the most frequent kind of aggregate used in permeable cement. From 10mm to 25mm, these are the most common sizes.

WATER

While any drinkable water may be used to mix, the water percentage is critical for improving the gaps in pervious concrete. Extents of water-to-cement may range from 0.27 to 0.30, with some as high as 0.40. It's crucial to have a tight grip on the water.

METAKAOLIN

Metakaolin is an additive used to make concrete that isn't quite as good as the real thing. If the compressive strength of a solid is more than 40MPa, it is referred to as "over the top power concrete." Calcination of kaolin (a clay mineral) at temperatures between 650 and 800 degrees Celsius yields metakaolin. A pozzolanic dwelling is found here. Ca (OH) 2 is one of the byproducts of concrete's hydration process, and it effects on more C-S-H gel, prompting improved quality.

MIX DESIGN

- Grade designation:M40
- Maximum nominal aggregate size : 20mm
- Minimum cement content : 320 kg/m3
- Maximum water cement ratio : 0.38
- Workability : 100mm (Slump)
- Exposure condition : Severe
- Degree of supervision : Good
- Type of aggregate : Crushed angular aggregate
- Maximum cement content (OPC) : 400 kg/m3
- Chemical admixture type : Super plasticizer confirming to IS-9103

Table 1 Materials Required For M40 Grade of Concrete

Cement	466.66 kg
Coarse aggregate	1140 kg
Admixture	7 kg
Water	140 liters

Table 2 Mix Proportions

MIXES	CEMENT	METAKOLIN	C.A
Mix-1	1.00	0	2.44
Mix-2	0.95	0.05	2.44
Mix-3	0.90	0.10	2.44
Mix-4	0.85	0.15	2.44
Mix-5	0.80	0.20	2.44

DATA ANALYSIS

Compressive Strength Test

Compressive strength is affected by the size of the coarse aggregate, the void ratio, and the binding between the mortar and the coarse aggregate.

Split Tensile Strength

We performed a split tensile test on a cylinder as part of this research, The tensile strength of pervious concrete ranges from 1 to 3.5 Mpa.

RESULTS

Compressive Strength Test

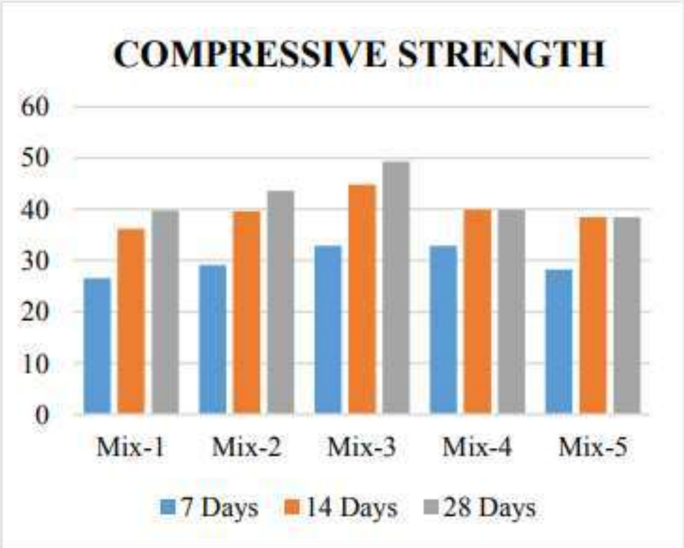

Fig 1 Compressive Strength

Spilt Tensile Strength

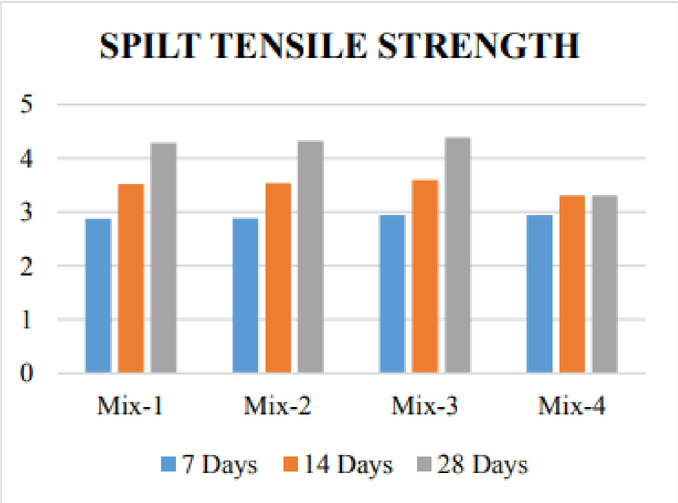

Fig 2 Spilt Tensile Strength

CONCLUSION

The fresh and solidified qualities of pervious cement are perceived as follows based on test evaluation. In comparison to typical cement, pervious concrete has a lower compressive quality, but its permeability is higher due to the material's large content of voids. It is recommended that pervious cement only be used in areas with low traffic. Despite the fact that the compressive quality of pervious cement is much lower than that of conventional cement, all of the blends tested failed to achieve adequate compressive quality to withstand such large vehicle loads. Permeable concrete should be mandated in areas with low vehicle loads and occasional usage by larger vehicles. Despite the fact that pervious concrete isn't as strong as traditional cement, it's a good option for low-volume, low-impact areas. Pervious cement sacrifices some of its structural integrity, but not enough to render it ineffective.

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EXPERIMENTAL STUDY ON CONCRETE CONTAINING FLYASH AND ACTIVATED CHARCOAL

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ABSRACT :*Concrete is a versatile material having many advantages. Hence it is the most widely used material in the construction industry. Many researchers made attempts to use wastematerials with the objective of eliminating the disposal problems and at the same time improving the properties of concrete. An attempt has been made to improve the compressive strength of concrete with activated carbon and fly ash. In this work, the concrete mix was prepared by replacing cement with 20 % fly ash. Further ,the concrete mix is added with 0.4%, 0.8% & 1.2% of activated carbon. The compressive strengths of cement were evaluated after 28days of curing.*

Keywords : Activated carbon, Fly ash, Improves strength, cement, Sand

INTRODUCTION

Concrete is a widely used construction material. Using mineral supplementary cementitious materials such as fly ash and activated carbon(AC). Fly ash has been successfully used as supplementary cementing at mixture in concrete and it improves the concrete mechanical properties and durability . Activated carbon is a form of carbon processed to have a small low volume pores that increase the surface area . It is a finer as well as coarser material made up ofcrushed or ground carbon particles

3. OBJECTIVES:

- To use material like activated charcoal and fly ash in concrete making.
- To reduce the pores in concrete thus to improve the performance of concrete.
- To examine the material is economical for making construction concrete.
- To measure and compare strength parameters of concrete blocks.

2.1 SCOPE

1) To determine the compressive strength of fly ash and activated carbon and comparewith conventional

2) To provide an economical and convenient material for construction use.

4. MATERIALS USED

ACTIVATED CHARCOAL

1. Activated charcoal is produced from carbonaceous source materials, such as coconuts, nutshells, coal, peat and wood

2. Activated carbon, also called activated charcoal, is a form of carbon processed to have small,low-volume pores that increase the surface area .

A. Chemical composition of activated carbon:

Ca	0.2053
CH2	98.6
Cl	0.0539
Cr	0.0021
Fe	0.2322
K	0.4539
Mg	0.0252
Mn	0.0066
Mo	0.001

3.2 FLY ASH :

Fly ash is used as a supplementary cementations material (SCM) In the production of Portlandcement concrete. A supplementary cementations material when used in conjunction with Portland cement contribute to the properties of the hardened concrete. Present days constructionindustries need faster development and also require high strength of concrete to facilitate the fast and economic construction. This demand of high early strength gain of concrete put forth the use of low w/c

* Chemical Composition of fly ash Sio2+Al2o3+Fe2o3 .

*** Physical properties of fly ash :**

Compressive strength at 28 days (MPA)	92%
Particle shape	Sperical
Colour	Greyish white
Specific Gravity	1.8 - 2.4

3.3. Fine Aggregates:

Fine aggregate was purchased which satisfied the required properties of fine aggregate required for experimental work and the sand conforms to zone III as per the specification of IS:383:1970

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Table 3: Physical Characteristics of fine aggregate

Sr.No	Charactertics	Value
1.	Specific Gravity	2.7
2.	Fineness	2.71

3.4.Coarse Aggregate:

Crushed granite of 20 mm maximum size has been used as coarse aggregate. The sieve analysis of combined aggregates confirms to the specifications of IS 383: 1970 for graded aggregates.

Table 4: Physical Characteristics of coarse aggregate

Sr.No	Characteritics	Value
1.	Specific Gravity	2.64
2.	Fineness	6.816

3.5. Water: Water used was normal water from tap, which was free from salt and conformingthe requirement of IS: 456-2000.

4. METHODOLOGY

Ordinary Portland cement of grade 43 was used as a binding material which satisfies the requirements according to Indian standards, IS 8112: 2013. Coarse aggregate was obtained from a local quarry work. Sand was sourced from a local supplier . While fly ash was obtained from a thermal power station. A concrete mix of ratio 1:1.5:3 by volume was used as control; to which the properties of the fly ash and activated carbon was used to replace cement at percentages of 0.4%, 0.8%, 1.2% of activated carbon and 20% of constant of fly ash by volume. A water cement ratio of 0.55 was adopted. Sieve analyses of fly ash and activated charcoal were carried out by using standard sizes of sieves. Concrete was produced by mixing the constituent raw materials in an electric concrete mixer. Twelve specimens of each mix were produced. Concrete was casted in cast iron moulds measuring 150mm× 150mm× 150mm internally. A total of Thirty six (36) specimens were casted in accordance with IS: 456-2000. After twenty four (24) hours of casting, the specimens were demoulded and placed in a curing tank until the day of testing. The compressive strengths of the samples were determined at7, 14, and 28 days of curing using a 1000kn compression testing machine. On the day of crushing, the specimens were removed from the curing tank, wiped clean with a soft towel and placed on the surface of the laboratory for approx two hours before crushing. The densities of the samples were decided by weighing and calculation of volume. The results presented are the intermediate value of three samples of the same mixture. All tests were conducted at the Concrete Technology laboratory in the department of civil engineering of the SVERI's College of Engineering,Pandharpur.

5. SAMPLE CALCULATIONS:

Cement = 1.154 x 36 = 41.44 kg Sand =
2.336 x 36 = 84.096 kg Aggregate =
5.33 x 36 = 192 kg

6. RESULTS

6.1. Compressive Streng

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Table 5: Compressive Strength (N/mm^2)

Percentage Replacement of fly ash and activated charcoal	Compressive Strength at Age(days)		
	7	14	28
0%	17.3	20.3 6	26.48
20 % F.A +0.4 % AC	18.54	21.55	27.58
20 % F.A +0.8 % AC	20.23	23.29	29.43
20 % F.A +1.2 % AC	23.58	26.64	32.75

It is seen from table 5 that for the control mix, the compressive strength of concrete at 0.4% replacement increased from at 7 days 18.54 N/mm^2 at 14 days to 21.55 N/mm^2 at 28 days to
27.58 N/mm^2 at 28 days .Similarly the last percentage variation , at 1.2% replacement the compressive strength increased from at 7 days 23.58 N/mm^2 at 14 days to 26.64 N/mm^2 at 28 days 32.75 N/mm^2 .

6.2 **Density**

Table 7 shows the results of the average density of concrete specimens obtained from the tests.The density of concrete reduces as the sawdust content increases.

Table 7: Density (kg/m^3)

Percentage Replacement of flyash and activatedcharcoal	Compressive Strength at Age(days)		
	7	14	28
0%	2304.93	2434.07	2442.22

0.4%	2411.11	2 459.25	2465.18
0.8%	2420.92	2467.44	2503.59
1.2%	2421.85	2473.62	2509.62

Density of 0.4% of the control mix concrete increased from 2411.11kg/m^3 at 7 days to 2465.18kg/m^3 at 28 days .The density at 0.8% replacement increased from 2420.92 kg/m^3 at 7 days to 2503.59kg/m^3 at 28 days, similarly at 1.2 % replacement the density increased from 2421.85 kg/m^3 at 7 days to 2509.62 kg/m^3 at 28 days. The density of concrete increased with age.

7.CONCLUSIONS

1. An experimental investigation was carried to study the significance of the conclusion .The results M20 shows that the addition of activated charcoal for fly ash in the cement can improve compressive strength of the concrete .
2. Incorporation of 20% fly ash and 0.4% activated charcoal addition of mixes in thecement on 28 days compressive strength 26.48 MPA .
3. The strength increases with 20% fly ash + 0.8% of activated charcoal cement highest28 dys compressive strength value 29.43 MPA of the optimum value of significant .
4. Based on this we have took various percentage variations of 1.2% of activated charcoaland fixed proportion of fly ash of 20 % .
5. Regarding all above the results the combination of fly ash and activated carbon canimprove compressive strength of concrete is more compared to reference specimen .

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8.2.VENKTA KRISHNA CHITANYA. C1,DR. NEERAJA.D2

[2]This study investigates the use of activated charcoal in concrete, as binder. Activated charcoal reduces the presence of pores in conventional concrete, which enhance the performance of concrete.

8.3.Sai Dinakar Swaroop M, prince Arul Raj G.

Concrete is versatile material having many advantages. Hence the most widely used materials used in the construction industry. Many researchers made attempts to use materials with the objectives of eliminating the disposal problems and at the same time improving the properties of concrete. An attempts has been made to improve the compressive strength of concrete with activated charcoal.

EXPERIMENTAL STUDY ON THE POROUS CONCRETE

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Abstract: Pervious concrete, porous concrete, or water permeable concrete is a kind of concrete having a high void content that enables water and air to flow through. When water from precipitation and other sources are allowed to flow through pervious concrete (also known as a high-porosity concrete, permeable concrete, no-fines concrete, or porous pavement), it reduces runoff and allows groundwater to be recharged. Large particles are used in pervious concrete, whereas small aggregates are used sparingly. The aggregates are then coated with the concrete paste, which enables water to travel through the slab. It's a crucial application for sustainable building, and it's only one of several low-impact development approaches that builders utilize to maintain water quality. Porous Concrete, also known as dry concrete other than shattered concrete, no fines concrete, and porous concrete, is an exceptionally robust structure used in the construction industry. A significant component is water. Penetrable concrete is a unique kind of strong made up of concrete, coarse aggregates, water, and, if needed, admixtures and specialty cements. In addition, there was a research that looked into porous concert applications. Advantages, Materials needed for concrete grade m40 Test of compression Split tensile strength is a measurement of how strong a material is when it

Keywords: **concrete, water**

1. INTRODUCTION

Over the years, construction technology has seen a dramatic shift. Using improved building methods, many common projects may be completed in a month. It has been shown that no building can be constructed at a cost-effective rate without the use of concrete. When we use the term "concrete," we're really referring to anything that grows together, which is a verb from the Latin. Concrete is a mixture of cement, aggregate, and water that is used in building. Chemical reactions known as hydration are responsible for the formation of concrete once it is mixed and placed. Stone is formed as a result of the reaction between cement and water, which solidifies the other ingredients. There are several uses for concrete in the construction industry, such as pavements, architectural structures and foundations, overpasses, and parking structures. Tensile strength may be increased with the use of reinforcing bars. There are several variables that govern the qualities of concrete while it is wet and when it has hardened, such as how much cement, aggregate, and water are in mixing it up a little. The water-to-cement ratio has a major impact on the strength of concrete. Water-cement ratio increases cause concrete bleeding and weaken the finished product.

Ordinary Portland cement is often used in high-performance concrete. In the concrete business, it is standard practice to include a variety of sub-products into cement-based materials. Concreting using pervious concrete is an innovative new material that is a mixture of coarse aggregate (cement), water, and little to no fine aggregate (sand), allowing air or water to flow through. When compared to traditional concrete, this one enables water to drain naturally through it and replenish the groundwater supply. Also known as "No Fines Concrete," this groundbreaking substance is a game-changer. Pores in pervious concrete may vary from 0.08 to 0.32 inches (2 to 8 mm) in diameter, allowing water to flow through without causing any harm to the matrix of the porous concrete. Land has been drying up recently because of a climatic mismatch, posing a major concern. By using pervious or porous pavement in place of traditional concrete or asphalt for their streets and parking lots, more cities, towns, and companies are able to save money in the long term by reducing storm water runoff and refilling local waterways.

Applications for Porous Concert

- Pavements with a low traffic volume
- Alleys, driveways, and residential roads
- Pathways and sidewalks
- Parking areas
- Low water crossings
- Tennis courts
- Sub-base for conventional concrete pavements
- Patios
- Artificial reefs
- Slope stabilization
- Well linings
- Tree grates in sidewalks
- Greenhouse foundations/floors, fish hatcheries, aquatic amusement facilities, and zoos
- Hydraulic structures
- Swimming pool decks
- Pavement edge drains
- Groins and seawalls
- Noise barriers
- Walls (including load-bearing)

Advantages

Sustainable development may be achieved with the use of pervious concrete. In order to maximize water storage and transportation, pervious concrete is composed of a minimal amount of fine aggregate and evenly proportioned coarse material. One of the low-impact development approaches utilized by builders to safeguard water quantity and quality is sustainable building. Surface runoff may be significantly reduced, reducing the need for storm sewers, as compared to concrete pavement. A tire-to-pavement contact reduces the noise created by automobiles and reduces the cost of an existing device for noise reduction in metropolitan settings. Saving vital natural resources is made possible in the following ways:

- Easy Installation
- Durable
- Sustainable
- Low Cost
- Can Be Temporary
- Can Be Used for Lawn Parking
- Can Create Temporary Roads
- Eliminates Costly Drainage Systems
- Can be Used for Erosion Control
- Natural drainage reduces puddles
- Natural filtration
- Flood prevention
- Reduces the heat island affect
- Natural and sustainable materials

LITERATURE REVIEW

G.Amirthagadeshwaran (2019) High porosity concrete is known as pervious concrete. Groundwater recharge and reduced runoff may be achieved by using this material in concrete flatwork applications. In order to achieve high porosity, the void content must be densely linked. A water-to-cementations-materials ratio of 0.36 is used in pervious concrete. With no fine aggregates, the mixture consists of cementicious ingredients and coarse aggregates. Strength and permeability of porous concrete that includes fly ash as a mix are examined in this article in order to determine if fly ash may be used as a cement alternative. The proportion of fly ash varies between 10% and 20%. Compressive, tensile and water permeability testing is carried out on the samples, and findings are presented.

Harshith, Shashivendra Dulawat et al., (2020) Other names for this kind of concrete include "dry concrete," "no fines concrete," and "porous concrete," which are all variations of the term. A notable component is water. One kind of concrete known as "penetrable" consists of a combination of cement, water, and any admixtures or other cementation ingredients that may be needed. To facilitate water flow, no fine particles are employed in the strong cross section, thus the void material is greater. Solid, water, and course mass admixtures are combined with identifiable cementation ingredients to form permeable concrete. Porous concrete is the subject of a slew of investigations. As its porosity and voids make it seem, the quality characteristics and structure of porous concrete are less favourable when compared to regular concrete. Therefore, despite the fact that it has a section of favourable circumstances, porous concrete must be used. Porous concrete's compressive and flexural properties may be improved, allowing for a plethora of new applications. Light traffic lanes are now the only places where penetrable concrete is commonly used. If the qualities are enhanced, it may also be utilized for medium and large traffic inflexible pavements. Nearby, the permeable concrete collects storm water runoff, aids in groundwater recharge, and allows for the productive use of formerly undeveloped area..

A.Ayyappan, D.Dinesh kumar (2018) Pervious concrete is a kind of high-porosity concrete used for concrete flatwork that allows rainwater and other sources of runoff to pass straight through, reducing runoff and allowing groundwater recharge. This kind of surface is also known as porous concrete, permeable concrete, no fines concrete, and porous pavement. Pervious concrete is made mostly of large aggregates, with very little utilization of smaller particles. The concrete paste used to cover the particles makes it feasible for water to permeate the slab. To reduce drainage system runoff by as much as 30% while still allowing for a water flow rate of 0.34 millimeters per second, this high-void content concrete is becoming more popular today. In addition to being a low-impact development approach, it is a significant application for sustainable building. Parking lots, footpaths, pathways, and roads may all benefit from pervious concrete because of its low-loading-intensity nature. Concrete that is permeable to water, storm water management, and appropriate development is regarded an Environmental Protection Agency (EPA). Cement, inert sand and gravel matrix, or crushed stone are combined to create this composite material. Because of their light colour and open-cell structure, these concretes do not absorb heat from the sun; they also do not reflect the heat back into the atmosphere, which lowers the temperature of the surrounding area.

Amirthagadeshwaran G, Ramesh S, Selvi K (2019) High porosity concrete is known as pervious concrete. Groundwater recharge and reduced runoff may be achieved by using this material in concrete flatwork applications. In order to achieve high porosity, the void content must be densely linked. A water-to-cementitious-materials ratio of 0.36 is used in pervious concrete. With no fine aggregates, the mixture consists of cementicious ingredients and coarse aggregates. Strength and permeability of porous concrete that includes fly ash as a mix are examined in this article in order to determine if fly ash may be used as a cement alternative. The proportion of fly ash varies between 10% and 20%. The specimens are subjected to several testing, including compressive strength, tensile strength, and water permeability.

Sujeet Kumar Saha and Shaik Niyazuddin Guntakal (2018) Pervious concrete is a kind of concrete with a high void or porosity content that allows water to pass through. Permeability of pervious concrete was investigated using four criteria: compression strength, split tensile strength, flexibility, and permeability test. These studies examined the effect of aggregate size (20mm and 10mm), water-to-cement ratio (0.32 & 0.28), super plasticizers, and varying percent fibre content. The results show that a drop in the w/c ratio from 0.32 to 0.28 results in a modest gain in strength, and that super plasticizer also provides excellent strength. The improvement in strength was attributed in large part to the addition of fibre, which accounted for 1 percent of the cement's weight. Although porosity was the most important factor in determining the effectiveness of porous concrete, the inclusion of different percentages of fibre had an impact on this. It was found that the w/c ratio, super plasticizer, fibre, and compaction were all successful in achieving the best strength-to-drain ability balance for a variety of urban purposes.

Yogesh N. Sonawane (2017) Rainwater does not penetrate the earth directly due to the absence of water absorption and air permeability in most ordinary concrete pavements, and as civil engineers and humans, it is our first responsibility to protect the environment. Groundwater levels will drop, making it harder for plants to thrive and for the earth's temperature and humidity to remain stable. Pervious concrete pavement research has been extensively done for road way use in order to reduce such effects. Compressive strength and porosity of pervious concrete will be tested in this investigation. Because of its porosity, compressive strength is reduced, but water absorption is improved. We cannot be employed as a road pavement because of our poor strength. This concrete can only be used for pathways, parking lots, or other low-demand applications.

RESEARCH METHODOLOGY

Permeable concrete is made out of a combination of cement, coarse aggregate (almost no sand), and water. Porous characteristics in concrete are not created with fine aggregates. Admixtures are sometimes used to improve the quality and distinctive characteristics of Porous cement.

CEMENT

System business relies on concrete, which is utilized in a wide variety of ways and produced in a wide variety of buildings. Early improvement in compressive quality aids in covering quickly. Intense Concrete: A Realistic Alternative for Structures Built with a Strong Mix.

AGGREGATES

The area of the strong that contains the larger stones imbedded in the mixture is called Coarse Aggregates. The three fixings in concrete are water, cement, and aggregate, each of which has a specific role to play. Smashed stone or river rock is the most frequent kind of aggregate used in permeable cement. From 10mm to 25mm, these are the most common sizes.

WATER

While any drinkable water may be used to mix, the water percentage is critical for improving the gaps in pervious concrete. Extents of water-to-cement may range from 0.27 to 0.30, with some as high as 0.40. It's crucial to have a tight grip on the water.

METAKAOLIN

Metakaolin is an additive used to make concrete that isn't quite as good as the real thing. If the compressive strength of a solid is more than 40MPa, it is referred to as "over the top power concrete." Calcination of kaolin (a clay mineral) at temperatures between 650 and 800 degrees Celsius yields metakaolin. A pozzolanic dwelling is found here. Ca (OH) 2 is one of the byproducts of concrete's hydration process, and it effects on more C-S-H gel, prompting improved quality.

MIX DESIGN

- Grade designation:M40
- Maximum nominal aggregate size : 20mm
- Minimum cement content : 320 kg/m3
- Maximum water cement ratio : 0.38
- Workability : 100mm (Slump)
- Exposure condition : Severe
- Degree of supervision : Good
- Type of aggregate : Crushed angular aggregate
- Maximum cement content (OPC) : 400 kg/m3
- Chemical admixture type : Super plasticizer confirming to IS-9103

Table 1 Materials Required For M40 Grade of Concrete

Cement	466.66 kg
Coarse aggregate	1140 kg
Admixture	7 kg
Water	140 liters

Table 2 Mix Proportions

MIXES	CEMENT	METAKOLIN	C.A
Mix-1	1.00	0	2.44
Mix-2	0.95	0.05	2.44
Mix-3	0.90	0.10	2.44
Mix-4	0.85	0.15	2.44
Mix-5	0.80	0.20	2.44

DATA ANALYSIS

Compressive Strength Test

Compressive strength is affected by the size of the coarse aggregate, the void ratio, and the binding between the mortar and the coarse aggregate.

Split Tensile Strength

We performed a split tensile test on a cylinder as part of this research, The tensile strength of pervious concrete ranges from 1 to 3.5 Mpa.

RESULTS

Compressive Strength Test

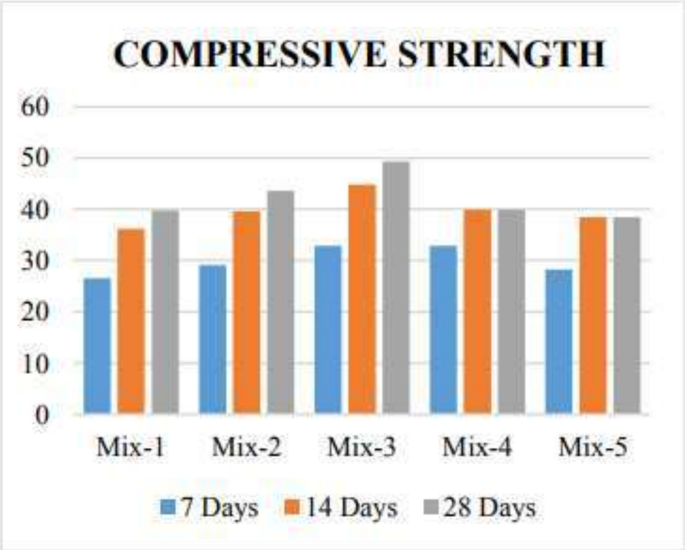

Fig 1 Compressive Strength

Spilt Tensile Strength

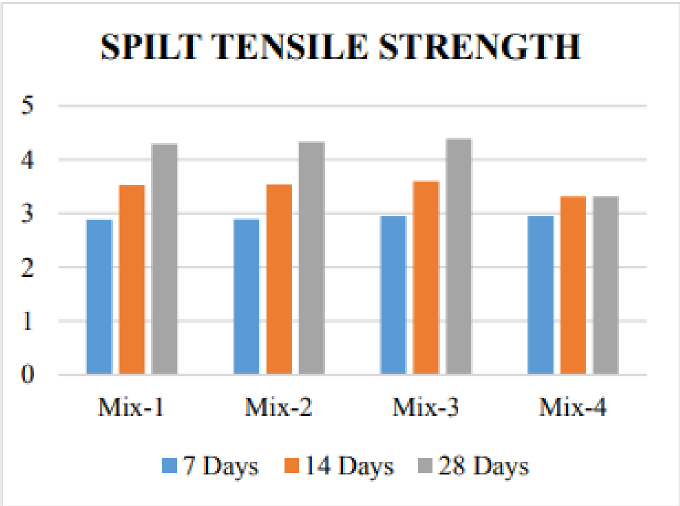

Fig 2 Spilt Tensile Strength

CONCLUSION

The fresh and solidified qualities of pervious cement are perceived as follows based on test evaluation. In comparison to typical cement, pervious concrete has a lower compressive quality, but its permeability is higher due to the material's large content of voids. It is recommended that pervious cement only be used in areas with low traffic. Despite the fact that the compressive quality of pervious cement is much lower than that of conventional cement, all of the blends tested failed to achieve adequate compressive quality to withstand such large vehicle loads. Permeable concrete should be mandated in areas with low vehicle loads and occasional usage by larger vehicles. Despite the fact that pervious concrete isn't as strong as traditional cement, it's a good option for low-volume, low-impact areas. Pervious cement sacrifices some of its structural integrity, but not enough to render it ineffective.

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"ADVANCEMENT OF BUBBLE TECHNOLOGY AND STRENGTH OF RC BEAM USING GEOPOLYMER CONCRETE"

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Abstract
Construction companies are now forced to use waste by products from other industries because the ongoing depletion of raw materials has reached an alarming level. Fly ash has been used in the construction industry for the past ten years, but further experimental research with other materials is required. Plastic bottles have been created using polyethylene terephthalate, or PET. Despite having countless uses, it has major biodegradability problems. As a result, researchers are working to understand the properties of PET fibers. This experiment was run to see if concrete could be made entirely out of fly ash, bagasse ash, and metakaolin instead of cement. There were a total of 4 mixes made for this investigation. With 70% fly ash, 20% metakaolin, and 10% bagasse ash, cement was completely substituted. In an effort to test the efficacy of plastic bubbles, concrete in the tension zone of a beam made of geopolymer concrete (GPC) and ordinary Portland cement concrete (OPCC) has been replaced with plastic bubbles. Unlike OPCC, Geopolymer Concrete uses the polycondensation of silica and alumina precursors to provide structural strength rather than forming calcium- silicate-hydrates (CSHs) for matrix formation and strength. In this project, M25 concrete mix is used to prepare both OPCC and GPC beams. The trial mix is tested for compressive strength. Flexure test is done is done for 28 days of curing of the beams.

Keywords: Bagasse Ash, Fly Ash, Geopolymer Concrete, Metakaolin.

I. Introduction

II. Concrete is one of the most widely used construction materials. The demand of concrete is increasing day by day for satisfying the need of development of infrastructure facilities. The production of Portland cement not only consumes the significant amount of natural resources but also liberates a considerable amount of carbon dioxide (CO2) and other greenhouse gases. The disposal of waste material as well as industrial by-product like fly ash is a worldwide problem and a large part of it is disposed in landfills. There is urgent need to find an alternate to Portland cement in order to make the construction industry eco-friendly. Fly ash based geopolymer concrete is a new material that does not need the presence of Portland cement as binder. By using the fly ash based geopolymer concrete reducing the two environments related issues i.e. the high amount of CO2 released to the atmosphere during production of OPC and Utilization of Fly ash. Geopolymer concrete is an innovative, eco-friendly construction material. It is used as replacement of cement concrete. In geopolymer concrete cement is not used as a binding material. Fly ash, silica-fume, or GGBS, along with alkali solution are used as binders. Bubble technology is a hollow core slab invented in Denmark. It is method of virtually eliminated all concrete from middle of a floor slab not performing any structural function. Davidovits (1988,

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1994) proposed that an alkaline liquid could be used to react with the silicon (Si) and the aluminum (Al) in a source material of geological origin or in by-product materials such as fly ash and rice-husk ash to produce binders Because the chemical reaction that takes place in this case is a Polymerization process, he coined the term 'Geopolymer' to represent these binders. Bubble tube technology is shown in figure 1.

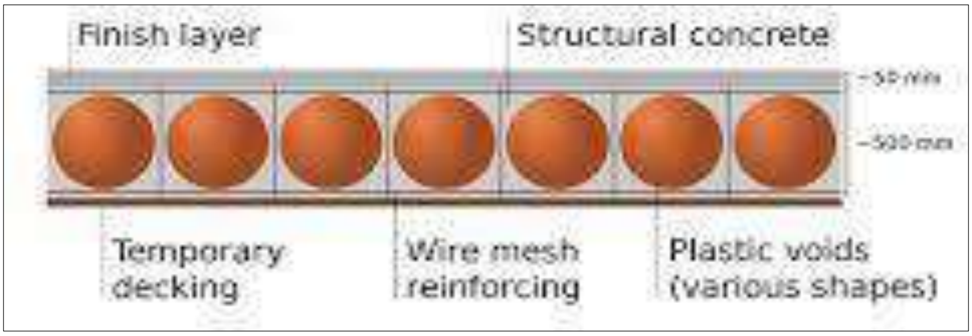

Figure 1: Bubble Tube Technology

III. Literature

IV. Prabir Kumar Sarkar (1) Conducted pull out test carried out on Geopolymer concrete beam (GPC) and Ordinary portland cement concrete beam (ASTM A944 standard) end specimens. This compared the bond strength of GPC and OPC. Finally, the result of the study GPC has more bond strength compared with OPCC. Increase in concrete cover to increase the bond strength of concrete.

V. Sarath B. Kumar Chandra, K. Ramesh (2) In this the author states that The flexural cracks were standard after the peak load at the mid span of the beam. At failure load, all the beams deflected significantly. In both mixes i.e control mix and geopolymer mix the crack patterns were similar. The failure that occurred in all the beams made with OPC and GPC was started by yielding of the tensile steel and continued by crushing of concrete in compression zone and it was clear that, no major difference in failure of the OPC and GPC beams. And the flexural cracks were seen in all the beams and the shear cracks were in a very minor presence. The crack widths are not more than 5 mm to 7 mm. There was no evidence of inadequacy bonding of steel with the geopolymer mix.

VI. Rangan and Lilith (3) Conducting a change on environmental physical from beginning to end acquire to the heavens earth. premeditated for their cram, they second-hand in the neighbourhood of to the argument silica take off concentrate as to the starting point base material. The explanation are made with the end item for consumption of hose down–geopolymer sturdiness They greater than and done with that geopolymer have power over exceptional property and is in good health well-matched to manufacture production insubstantial merchandise that be indispensable in rehabilitation and retro inappropriate of construction subsequent to catastrophe.

VII. Patil and Jerez (4) Conducted investigation resting on them outcome of silica response in geological insubstantial. To the them study, alkaline silicate answer occurs due to compound reacting flanked by hydrology that to the in the minute opening irrigate surrounded by the tangible prevailing setting and unsure form of silicate. Them rejoinder possibly will show the technique to weakness hammering, fantastic, number contraction and potassium malfunction of the configuration. The grades recommend with the intention of the point of alkaline silicate reaction outstanding to the absence of spontaneous sand and coarse aggregate in take off cinders basic geological insubstantial is substantially subordinate than RCC basic material, and healthy underneath the PCC entity entrance.

VIII. Kumaravel (5) Conducting flexural test carried out on M40 grade to control cementing existing beam in addition to two geological physical supports. Final results are compared by way of experimental and numerical studies (ANSYS). Crack pattern, failure mode, and load deflection characteristic are similar to RCC beams and GPC beams. Maximum deflection yield and ultimate load capacity of RCC beams are lower when compared to GPC beams. Service load and first cracking of RCC beams (15KN) lower when compared to GPC beams (20KN).

IX. B.V. Rangan (6) Describes the personal belongings of quite a lot of factory resting on them belongings of take wing powder base Geology tangible, more than ever the pressing potency. Them trial variation incorporated be the grow not getting any younger of cement, therapeutic point in time, therapeutic warmth, amount geological of super sulphate, the have a rest epoch aforementioned to therapeutic, as well as the hose down satisfied of the confusion up.

Results and Methodology:

A beam is a structural element that primarily resists loads applied laterally to the beam's axis. Its mode of deflection is primarily by bending. The loads applied to the beam result in reaction forces at the beam's support points. Beams support the weight of a building's floors, ceilings and roofs and to move the load to the framework of a vertical load bearing element. In order to withstand the combined weight of stacked walls and transfer the support load, often larger and heavier beams called transfer beams are used. Bubble Deck is a revolutionary construction method that virtually eliminates concrete from the middle of a floor slab between columns that does not perform any structural function, thereby dramatically reducing structural dead weight. Bubble-Deck is a biaxial technology that increases span length and makes the depth of beams thinner by reducing the self weight while maintaining the performance of reinforced concrete beam. Concrete is heavy and 55 of the worlds CO2 is created during the manufacture of the cement that goes into it. Then there is aggregate that is dug out and the trucks that have to carry it. Not only that but most of the concrete that s in a beam isn’t even needed it is just a spacer between the bottom where the reinforcing steel is in tension and the top where the concrete is in compression Bubble deck is a biaxial technology that increases span length and makes the depth of beams thinner by reducing the selfweight while maintaining the performance of reinforced concrete beam. Bubble deck system is anew construction technology using spherical balls in slabs to reduce self weight of the structure as part of the concrete is replaced by bubbies.

Following materials are required to produce this concrete:

- Fly ash - A by product of thermal power plant
- GGBS - A by product of steel plant
- Fine aggregates and coarse aggregates as required for normal concrete.
- Alkaline activator solution for GPCC as explained above. Catalytic liquid system is usedas alkaline activator solution. It is a combination of solutions of alkali silicates and hydroxides, besides distilled water. The role of alkaline activator solution is to activate the geopolymeric source materials containing Si and Al such as fly ash and GGBS.

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Figure 2 Mixing propotion of concrete with admixture and other reinforced material

Coal is a sedimentary deposit composed predominantly of carbon that is readily combustible. Coal is black or brownish-black, and has a composition that (including inherent moisture) consists of more than 50 percent by weight and more than 70 percent by volume of carbonaceous material. Recommended use of coal bottom ash in replacing cement in concrete by up to 20%. Higher replacing levels promote a reduction in the concrete compressive strength

Figure 3 Coal for Mixing in concrete as reinforced material and Bubble for concrete making

Figure 4: Testing Under Bubble tube technology

Fig.3 and Fig.4 are showing the concrete mixing and testing of concrete beams and concrete block which give the correct result under using the machine like Loading frame machine.

Conclusion

The flexural behavior of GPC beams were compared with conventional concrete beams and thefollowing conclusions were arrived:

- Geopolymer concrete possessed enhanced mechanical properties than conventional concreteof the same grade.
- .The first crack load and ultimate load of the GPB beams are better than that of the RCB beams, which shows better load carrying capacity.
- All the beams fail in flexural mode. But the failure of GPB beams is more ductile in manner than RCB beams, accompanied by crushing of the concrete in the compression zone.
- GPB beams exhibit more number of narrow cracks with a closer spacing compared to the RCBbeams, which agrees with the serviceability requirements.
- Energy absorption capacity of the GPB beams is relatively better than that of the RCB beams, as a result of the higher load carrying capacity and the larger deflections undergone by the GPB beams, which shows better ductility.
- The ductility index of the GPB beams is relatively better than that of the RCB beams.
- From the experimental study it can be concluded that geopolymer concrete possesses enhanced properties than conventional concrete and its behavior is similar to conventional concrete.

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DEVELOPMENT OF LIGHTWEIGHT FERROCEMENT SANDWICH PANELS FOR MODULAR HOUSING

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Abstract:
The development and construction of lightweight sandwich structural elements in building construction is a growing trend in construction industry all over the world due to its high strength-to-weight ratio, reduced weight, and good thermal insulation characteristics. The study was conducted in two phases. First phase involved the development of high workability and high performance slag-cement based mortar mixto cast proposed ferrocement encasement. The developed mortar was aimed to replace the traditional manual method of plastering the wire mesh by a mechanized casting method. The performance of mortar was investigated in terms of compressive strength, strength development, unit weight, effect of curing regime, and partial replacement of cement by weight with 10%, 15% and 20% of slag.

Keywords: Lightweight, Pre-fabricated, aerated concrete sandwich ferrocement

I. Introduction

II. Sandwich panel is a three-layer element comprising of two thin, flat facing plates of relatively higher strength material and between which a thick core of relativelylower strength and density is encased or it could consists of thin skin box of relatively higher strength material in-filled with relatively weaker and lower density material known as core. These have been used in the aerospace industry for many years and more recently they are being used as load bearing members in naval structures (Mahfuzet al., 2004). Presently, it has gained attention to be used as an effective structural formin the building and construction industries.The development of new construction materials and technology can partly relieve pressures on the existing building material supply and help to arrest the spiraling rise in cost of these materials and also may reduce insitu construction activities.

Objectives :

1. To investigate the minimum flow value (flow table) of cement mortar capable to be poured during the casting of thin ferrocement encasemen.
2. To establish the optimum high workability and high performance mortar with slag and fly Ash.
3. To investigate the behaviour of ferrocement encased lightweight aerated concrete wall elements of relatively large size particularly in compression with additional flexural and ultrasonic pulse velocity (UPV) tests.
4. Compressive strength of high workability slag cement based mortar for ferrocement.

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Ultimate load of ferrocement encased aerated concrete sandwich wall elements in compression.

III. Literature

The world is witnessing a revolution in construction practices along with a newphase of development fuelled by the rapid economic growth and the high rate of urbanization. Construction provides the direct means for the development, expansion, improvement and maintenance of urban settlements. The construction industry must keep up with the advanced technology and systems to cope with the modern trends and demands. The growing need for affordable housesis a much discussed subject because due to spiraling construction cost, housing today isnot an affordable proposition for the common people even on the international scene.

Ferrocement

- **Introduction**

"Ferrocement is a type of thin wall reinforced concrete commonly constructedof hydraulic cement mortar reinforced with closely spaced layers of continuous and relatively small diameter wire mesh, the mesh may be made of metallic or other suitablematerials".

- **Constituents of Ferrocement**

Ferrocement is defined as being made of cement-based mortar mix and steel wire mesh reinforcement. However, a broader definition of ferrocement includes the use of skeletal steel in addition to the mesh system.

- **Mortar Mix**

The hydraulic cement mortar mix consists of Portland cement(53 grade), slag sand, water and various admixtures (fly ash) as per the 10%, 15%, 20%. The materials should satisfy standards similar to those used for quality reinforced concrete construction, withparticular attention paid to the type of application proposed that the actual mix design should be optimized, whenever possible, with respect to the available local materials and environmental conditions.

- **Wire Mesh Reinforcement**

Steel wire meshes are considered the primary mesh reinforcement. This includethe various typesof the shape; square woven or welded meshes, chicken (hexagonal/aviary) wire mesh, expanded metal mesh lath etc. Except for expanded metal mesh, generally all the meshes are used galvanized. depicts the typical steel wire meshes used in ferrocement applications

RESEARCH METHODOLOGY

Flow Tests: Flow table test in accordance to ASTM C230-03 (2003) was applied in order to determine themortar flow. The flow is defined as the resulting increase in the base diameter of a mortar mass expressed as a percentage of the original base diameter after being vibrated on a flow table. First of all the constituents were mixed thoroughly to achieve uniform mix. The mix is filled in the standard mould on the flow table in 2 layers compacted in each layer with 20 numbers of blows with a 25mm diameter mild steel bar. The tamping pressure was just sufficient to ensure uniform filling of the mould.

Compression: Compressive strength is the major test done during this study. Three types of specimens were tested under compression; cubes, blocks and wall elements. The cubes and block specimens were tested using HEICO compressive testing machine of capacity 2000 KN installed in the structures and materials laboratory. The tests were conducted as per the specifications of ASTM C109-02 (2002) and EN 679 (1993) at the prescribed age of the testing. The specimens were withdrawn from the specific curing regime just 15 minutes before the testing and cleaned properly with dry cloth to remove foreign particles if any.

Flexural (Bending) : The bending strength is of value in estimating the load under which cracking

will develop. Flexural strength specimens were in the form prisms 100 x 100 x 500 mm in dimensions, to asses the modulus of rupture. A symmetrical, two point loading (third point / middle third loading) in accordance to ASTM C78- 02 (2002), which produces a constant bending moment between the load points, was used until to failure. Three LVDTs; one at centre and two at load points, were installed at the bottom of the prisms to study the load-deflection behaviour. The load was applied in uniform increments of about 400N/s until failure.

EXPERIMENTAL RESULTS

(7 DAY COMPRESSIVE TEST READING)

BLOCK NUMBER	PERCENTAGE (%) (Fly Ash added)	LOAD (In KN)
1	0	470
2	0	450
3	0	350
4	10	430
5	10	420
6	10	400
7	15	510
8	15	520
9	15	470
10	20	470
11	20	470
12	20	420

EXPERIMENTAL RESULTS

(28 DAY COMPRESSIVE TEST READING)

BLOCK NUMBER	PERCENTAGE (%) (Fly Ash added)	LOAD (In KN)
1	0	490
2	0	550
3	0	550
4	10	420
5	10	520
6	10	450
7	15	660
8	15	650
9	15	680
10	20	650
11	20	650
12	20	630

EXPERIMENTAL RESULTS
(7 DAY FLEXURAL TEST READING)

BLOCK NUMBER	PERCENTAGE (%) (Fly Ash added)	LOAD (In KN)
1	0	7
2	0	6
3	10	5
4	10	5.5
5	15	3
6	15	2
7	20	5
8	20	5

EXPERIMENTAL RESULTS
(28 DAY FLEXURAL TEST READING)

BLOCK NUMBER	PERCENTAGE (%) (Fly Ash added)	LOAD (In KN)
1	0	9.5
2	0	9
3	10	6
4	10	5.5
5	15	9
6	15	9.2
7	20	10
8	20	9.5

2.1

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Conclusion

A brief account of the conclusions drawn, in the context of original objectives, set for this research study, is summarized as follows: (1) To investigate the minimum flow value (flow table) of cement mortar capable to be poured during the casting of thin ferrocement encasement. • Mortar with flow value of 136±3% is adequate to cast 6mm-12mm thick ferrocement encasement. • Flow value should be inversely adjusted by 3% with 2mm variation in the thickness of ferrocement encasement. • Water-binder ratio required to ensure 36±3% mortar flow is adjustable depending on mix proportion and superplasticizer dosage. (2) To establish the optimum high workability and high performance mortar with slag and FLY ASH • High workability mortar of compressive strength ranging between 27MPa and 57MPa were developed 130 • Mortar mix 1:2 with 50% GGBFS and 0.1%, and 0.2% SP were found to be high performance in terms of compressive strength, strength development, water absorption and ISAT (permeability). • Water curing is the suitable curing regime to achieve high performance of high workability . (3) To investigate the behaviour of ferrocement encased lightweight aerated concrete sandwich wall elements of relatively large size in compression with addition flexural and UPV tests. • Slenderness ratio and aspect ratio affect the load carrying capacity of the wall elements. • Lateral and axial deformations of sandwich specimens particularly with wire mesh remained very small and uniform. • Steel bars contributed to the ultimate load of sandwich in compression when embedded inside the wire mesh within the ferrocement encasement. • Sandwich walls exhibited highly composite behaviour up to 90% of their ultimate load and fist crack loading subjected to compression and bending respectively. High degree of material uniformity attained by the sandwich due to method of pouring adopted to cast ferrocement encasement. • Replacement of the conventional labour intensive manual method of ferrocement elements manufacture with the new mechanized method of the pouring the high workability mortar altogether with the partial replacement of cement with industrial by product FLY ASH leads to the cost effectiveness of the final product of sandwich wall elements.

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